A Comparison of Actual and Apparent Lumbar Lordosis in Black and White Adult Females

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The purposes of this study were to investigate differences in lumbar lordosis in black and white adult females and to explain the clinical impression that blacks have a greater lordosis than whites. An actual lumbosacral lordosis angle (ALS) was measured from a standing right lateral lumbosacral radiograph using the angle formed from the intersection of lines drawn across the top of the second lumbar vertebral body (L2) and across the top of the sacrum. An actual lumbo-lumbar angle (ALL) was measured in the same manner, except the second line was drawn across the bottom of the fifth vertebral body (L5). To determine whether gluteal prominence gives a false impression of increased lumbar lordosis, an apparent lordosis (APL) measurement was taken, measuring the distance from the subject's greater trochanter to the most posterior aspect of the buttocks. No significant differences were found in ALS or ALL between 25 black and 27 white adult female subjects (ALS, $P = 0.26$; ALL, $P = 0.41$). Significant differences were found between black and white APL, with blacks demonstrating a larger APL than whites ($P < 0.01$). A high correlation was noted between ALS and ALL in both blacks (0.70, $P < 0.01$) and whites (0.77, $P < 0.01$). The investigators therefore contend that the clinician's assumption that blacks have a greater lordosis than whites is based on an apparent increased lordosis due to more prominent buttocks (APL). [Key words: lumbar lordosis, lumbosacral radiograph, gluteal prominence, apparent lumbar lordosis]

LOW-BACK PAIN remains one of the nation's most frequent clinical complaints and is one of industrial society's most extensive and expensive health problems.[6,17] Approximately 80% of all adults will experience some low-back pain at least once during their lifetime.[8] Although several factors influence the development of low-back pain, they are not fully understood. Among the abnormalities cited as contributing factors in low-back pain are severe lumbar scoliosis and severe lumbar lordosis.[9] Several authors cite a change in lumbar lordosis, decrease or increase, as a contributing factor in low-back pain.[7,14]

Several researchers have studied the lumbar spine radiographically, each finding different average lumbar lordosis angles and describing different techniques for radiographically measuring lordosis angles.[1-3,9,12,16,17] In a cadaver study of 182 specimens, Farfan et al[2] demonstrated a mean lumbar lordotic angle of 42°. He measured the angle that was subtended by a plane intersecting the disc spaces between the first and second lumbar vertebrae (L1-L2) and between the fifth lumbar vertebra (L5) and the sacrum (S1). Stagnara et al[16] demonstrated a standing lordosis mean angle of 56° in 100 adults, in whom the angle was measured from the top of the sacrum to the upper surface of whichever lumbar vertebra gave the largest angle. Using radiographs taken with subjects in the recumbent position and measuring the angle between the second lumbar vertebra's superior surface and the top of the sacrum, Fernand and Fox[3] demonstrated a mean lumbosacral angle of 47° for women and 43° for men. In addition, Fernand and Fox[3] were the only authors to demonstrate a significant difference in the lumbar angles between the genders.

In the clinical setting, lumbar lordosis is evaluated during the postural assessment of the patient. This postural assessment is made with the patient in the standing position.[5] Thus, in order to make comparable clinical and radiographic assessments of lordosis, both measurements should be taken in the same position. Lumbar lordosis is assessed clinically from a lateral view, either with or without the use of a plumb line as a vertical line of reference. In discussing the use of the plumb line in postural assessment, Kendall and McCreary[5] state that the standard of comparison to the 'ideal' posture is through the patient's skeletal alignment. They recognize that vast variations exist in individual sizes, shapes, and proportions, and propose that using the standard of skeletal alignment is a valid measure for assessing individual body posture regardless of body type. Kendall and McCreary[5] further state that because of the correlation between body contour variations and skeletal alignment variations, an experienced clinician is able to evaluate the position of the skeletal structures by inspecting the contours of the patient's body. We are not in agreement with this theory and suspect that a clinician's assessment of lumbar lordosis may be obscured by individual body types. In particular, we question a clinician's prejudgment of an individuals lumbar lordosis based on body type, in the absence of a thorough postural evaluation.

As an example of this prejudgment, in personal interviews with clinicians, the overall opinion was that blacks have an increased lordosis as compared with whites. This clinical impression has not been substantiated by research comparing lordosis values. Torgerson and Dotter,[17] Farfan et al,[2] and Stagnara et al[16] were unable to demonstrate any significant differences between males and females and did not address differences between blacks and whites. However, at a significance level of $P < 0.05$, Fernand and Fox[3] found no difference in lordotic curves between blacks and whites. Using an analysis of variance and Duncan's Multiple Range Test at the 5% level of significance, they demonstrated that in groups of black males, white males, black females, and white

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Fig 1. Derivation of APL (in cm). GT = Greater Trochanter.

females, significant differences existed between males and females but not between blacks and whites. Fernand and Fox[3] performed their study on patients with complaints of back pain who had roentgenograms taken in the recumbent position. However, they pointed out that the lordosis angle changes in standing as the spine becomes isolated, and they recommended a study using subjects with no complaints of low-back pain with roentgenograms taken in the standing position.

Stagnara et al[16] were the only authors to address apparent versus actual lordosis. In their study, they found no significant differences between male and female lordosis when measured radiographically, but observed that females showed an increased apparent lordosis during physical examination because of a larger gluteal prominence. The clinical impression that blacks have an increased lordosis may be because blacks demonstrate an increased apparent lordosis (APL) on physical examination as Stagnara et al[16] theorized with females; to date no one has investigated this theory. We agree with Fernand and Fox that blacks do not have a significant difference in lordotic curve as compared with whites. Further, we hypothesize that the clinician's perception of increased lordosis in blacks may be due to a larger gluteal prominence (apparent lumbar lordosis) seen in blacks. This prominence may make blacks appear to have an increased lordosis during postural examination.

The purposes of this study were to investigate possible differences in roentgenographic lordosis measurements between black and white women with no complaints of low-back pain. This study also described an objective method of measuring gluteal prominence and, using this measure, investigated whether differences existed in gluteal prominence between black and white adult females. In addition, this study was designed to examine the correlation of two different methods of radiographic measurements of lordosis.

METHODS

Before initiation of this investigation, the protocol for this research was approved by the Brooke Army Medical Center Department of Clinical Investigation, Fort Sam Houston, Texas. Volunteer eligibility for participation in this study was determined through completion of a questionnaire prior to subject involvement. Exclusion criteria included: current activity-limiting low-back pain; a history of activity-limiting low-back pain, spinal surgery or spinal anomaly, or possible pregnancy. Subjects also were excluded if they were overweight by U.S. Army standards.[18] Subject volunteers were derived from a population of U.S. Army Active Duty women between the ages of 18 and 40 inclusive. The sample consisted of 27 black and 29 white volunteers. All volunteers signed a volunteer consent form; underwent a Urine Beta-hCG Test[10] to confirm nonpregnancy; and passed the weight standards set forth by the Army.[18] Measures were obtained with the subjects in stocking feet and wearing shorts and a T-shirt.

Following height and weight measurements, an apparent lordosis (APL) measure of gluteal prominence was taken. To determine the most posterior aspect of the buttocks, the subject backed up to an adjustable height board until her buttocks first made contact with the board. The adjustable height board was vertical to the floor and positioned in such a manner that a pole attached perpendicularly to the board extended over the subject's right greater trochanter. This pole had a tape measure attached to it, and a measure of gluteal prominence (in cm) was determined by measuring from the board (most posterior buttock prominence) to the

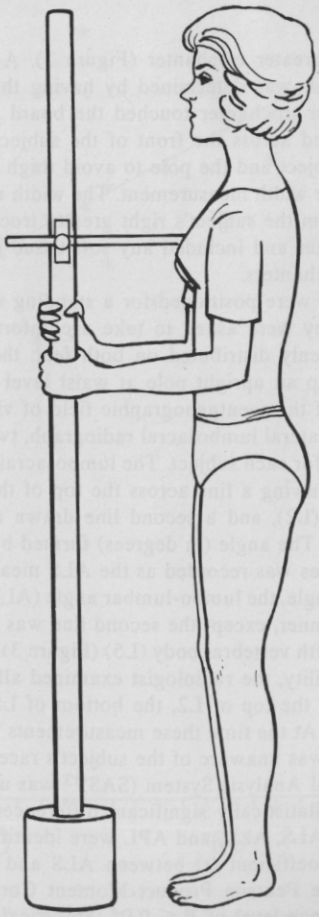

Fig 2. Subject positioning for right lateral lumbosacral radiograph.

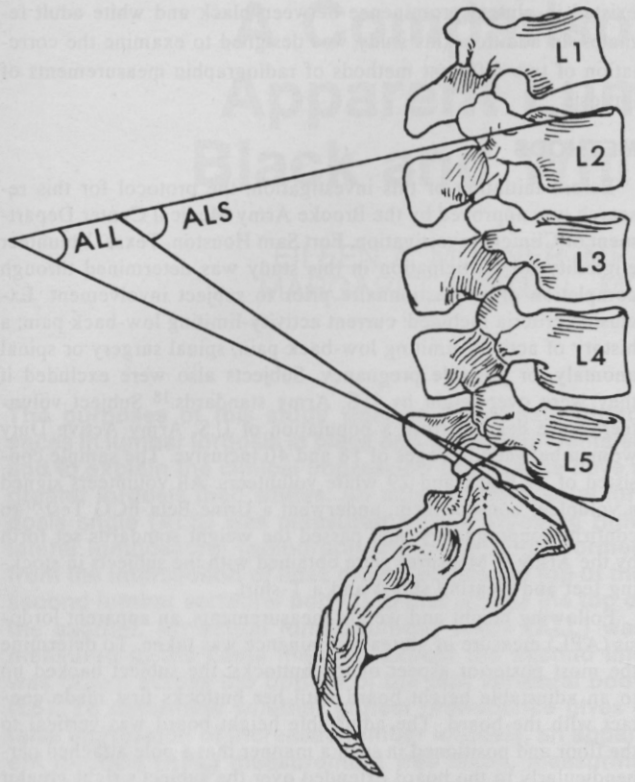

Fig 3. Derivation of ALS and ALL.

subject's right greater trochanter (Figure 1). A measurement of pelvic width also was determined by having the subject turn so her right greater trochanter touched the board and the horizontal pole extended across the front of the subject. Space was left between the subject and the pole to avoid thigh or abdominal interference of the width measurement. The width measurement was the distance from the subject's right greater trochanter to her left greater trochanter and included any soft tissue just lateral to the two greater trochanters.

Subjects then were positioned for a standing right lumbosacral radiograph. They were asked to take a comfortable stance with their weight evenly distributed on both feet; they then were instructed to grasp an upright pole at waist level so that the arms would be out of the roentgenographic field of view. (Figure 2).[16] From the right lateral lumbosacral radiograph, two lordosis angles were measured for each subject. The lumbosacral angle (ALS) was measured by drawing a line across the top of the second lumbar vertebral body (L2), and a second line drawn across the top of the sacral base. The angle (in degrees) formed by the intersection of these two lines was recorded as the ALS measurement (Figure 3).[3] A second angle, the lumbo-lumbar angle (ALL), was measured in the same manner, except the second line was drawn across the bottom of the fifth vertebral body (L5) (Figure 3).[3] To assure measurement reliability, the radiologist examined all roentgenograms and determined the top of L2, the bottom of L5, and the top of the sacral base. At the time these measurements were determined, the radiologist was unaware of the subject's race.

The Statistical Analysis System (SAS)[13] was used for all statistical analyses. Statistically significant differences between blacks and whites for ALS, ALL, and APL were identified using a t test. A correlation coefficient (r) between ALS and ALL was determined using the Pearson Product-Moment Correlation Analysis with a significance level of $P \leq 0.05$. Statistical significance of r was determined as described by Snedecor and Cochran.[15]

RESULTS

Two black subjects were not included in the statistical analyses when one presented with a compression fracture of the L2 vertebral body on radiograph, and one subject reported a previous history of activity-limiting low-back pain that she had not reported on the preliminary questionnaire. Two white subjects also were excluded from the statistical analyses because of a unilateral spondylolysis of L5 and a lumbarization of S1 noted roentgenographically. Thus, statistical analyses were performed using 25 black and 27 white female subjects.

Table 1 shows the demographics for the sample sizes according to race. The mean age for both groups was 25.3 years, with a range of 18 to 37 for blacks and 18 to 39 for whites. Mean heights for the two groups were similar, with 65.4 inches for blacks, with a range of 61 to 69, and 65.4 inches for whites, with a range of 60 to 70. White subjects had an average weight of 132.3 pounds, with a range of 95 to 176; Black subjects had a comparable average weight of 131.68 pounds, with a range of 103 to 167. Although the range for the weight is greater in the white sample size, the standard deviations (SD) for the two groups is very close (SD for blacks = 15.2, SD for whites = 17.0). As is evident from these statistics, the two groups were evenly matched by age, height, and weight.

Results of the t tests are shown in Table 2. From this table, there was no statistically significant difference in ALS between blacks ($t = 0.2560$) and whites ($t = 0.2597$); there also was no significant difference in ALL between blacks ($t = 0.4128$) and whites ($t = 0.4150$). Although pelvic width was not significantly different between the races ($t = 0.4780$ for blacks and $t = 0.4759$ for whites), gluteal prominence was significantly different, with $t < 0.01$ for both races.

Using the Pearson Product-Moment Correlation, ALS and ALL were highly correlated for both blacks and whites and for the sample groups as a whole (Figure 4). The correlation coefficient for blacks of $r = 0.77$, for whites of $r = 0.70$, and for the combined races of $r = 0.71$ were all statistically significant at the $P < 0.01$ level.

DISCUSSION

Only one study of lumbar lordosis measurements has previously addressed racial differences. Our finding of no significant difference in lumbar lordosis between black and white adult females supports the 1971 study by Fernand and Fox.[3] However, their investigation was done with subjects complaining of low-back pain and the roentgenograms were taken in the recumbent position. This study was, therefore, unique in several ways.

First, the study was unique in that the population was healthy adult women with no complaints of low-back pain; in addition, the population was ideal in that no subject was overweight in

Table 1. Sample Group Demographics According to Race

	Blacks (n = 25)			*Whites (n = 27)*		
	Age (yrs)	*Height (in)*	*Weight (lbs)*	*Age (yrs)*	*Height (in)*	*Weight (lbs)*
Mean	25.3	65.2	131.7	25.3	65.4	132.3
SD	5.3	2.1	15.2	5.3	2.6	17.0
Range	18-37	61-69	103-167	18-39	60-70	95-176

SD = Standard Deviation.

Table 2. *T*-Test Results for ALS, ALL, APL, and Pelvic Width (PW) Between Blacks (n = 25) and Whites (n = 27)

		Mean (±SD)	*Range*	t *value*	P *value**
	Black	54.4(7.1)	40-69	1.1	0.26
ALS†					
	White	51.8(8.8)	36-66	1.1	0.26
	Black	42.2(8.2)	28-60	−0.8	0.41
ALL†					
	White	44.2(9.3)	30-62	−0.8	0.42
	Black	16.9(2.4)	12.5-23	4.3	0.0001
APL‡					
	White	14.4(1.6)	11.3-17.8	4.4	0.0001
	Black	42.9(2.4)	38.3-46.5	−0.7	0.49
PW‡					
	White	43.3(2.2)	36.0-46.4	−0.7	0.49

ALS = actual lumbosacral lordosis angle; ALL = actual lumbo-lumbar angle; APL = apparent lordosis.
*Probability of $P > t$.
†Mean, SD, and range measured in degrees.
‡Mean, SD, and range measured in cm.

accordance with U.S. Army height and weight standards.[18] The issue of height and especially weight is important since obesity may contribute to increased lordosis.[11] As seen in Table 1, the two groups were well matched by age as well as height and weight.

This study also differed from Fernand and Fox's[3] work in that the subject's roentgenograms were taken in the standing position. Not only does standing load the spine, thus changing postural curves,[14] but standing is the position used clinically for postural assessment.[5] Thus, for research of lumbar lordosis, standing roentgenograms are more clinically applicable.

From the literature review, many different methods of measuring lumbar lordosis on radiograph have been used, with obvious different results, depending on the levels used. This study was designed to compare two different methods, ALS and ALL, of measuring lumbar lordosis.

Vast differences occurred between ALS and ALL measures in individual subjects. For example, one subject had an ALS measure of 52° and an ALL measure of 30°, while another subject had an ALS measure of 61° and an ALL measure of 43°. Although these differences were present, they were not significant, as a high correlation existed between ALS and ALL for both races and the combined group (Figure 4). Actual lumbo-lumbar angle is correlated to ALS because the lumbar vertebrae adjust their alignment according to the position of the sacrum.[4] When the sacrum is more horizontal, the lordosis adapts by increasing; with a more vertical sacrum, the lordosis decreases.[4] Because of this strong influence of the sacrum on the lordotic curve, ALS is a more accurate assessment of lumbar lordosis because it includes the sacrum. Therefore, research or clinical assessment of lordosis should include the sacrum.

Investigator bias was controlled in this investigation by accepting all volunteers meeting the Army weight standards,[18] avoiding postural assessment before the completion of all measurements, and not revealing subject races to the radiologist measuring the roentgenograms. The possibility for bias or error in the APL measure does exist, however, since the investigator made the judgement as to when the buttocks first made contact with the measur-

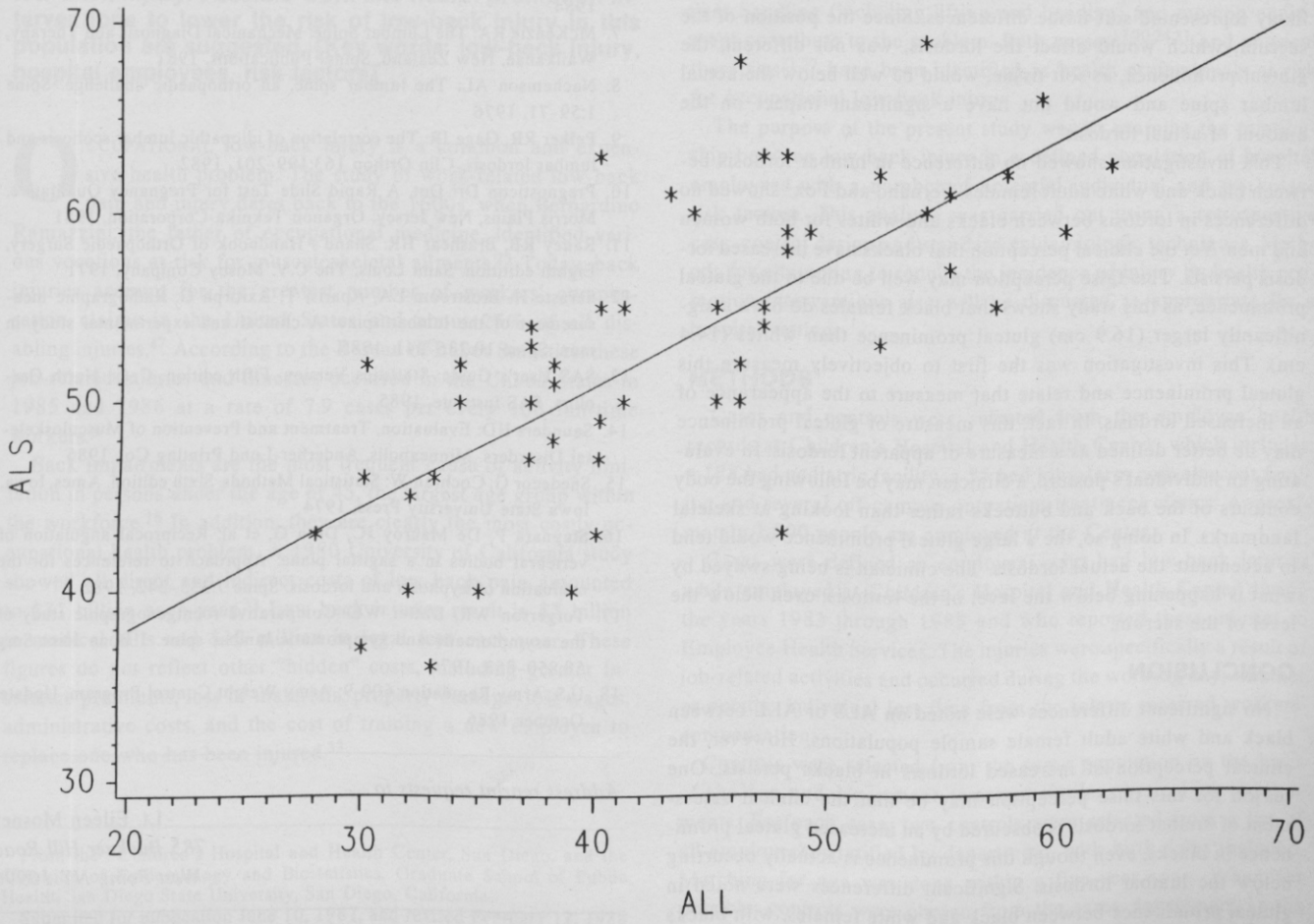

Fig 4. Correlation plot of ALS and ALL for all subjects (correlation coefficient $r = 0.71$, $P = 0.0001$, n = 52.

ing board discussed in the methods section. In this measure, the investigator also was aware of the race of the subject. However, this measure was the most objective one available to us at the time. The difference in APL between blacks and whites was so statistically significant that it would be difficult to argue this difference was purely due to investigator bias.

Because this study defined the gluteal prominence measure (APL), the measurement must be established as a reasonably valid measure of prominence and not of hip girth. An obvious potential contributor to a measure of gluteal prominence would be overall increased hip or pelvic girth. To control for that possibility, the pelvic width measurement was taken. To eliminate the possibility of a protruding abdomen affecting the measure, pelvic width was chosen as an indicator of girth rather than using actual girth measurements. As shown in Table 2, the pelvic widths were not significantly different between the races, with an average of 42.9 cm for blacks and 43.3 cm for whites. Because the width measurements were not different, the measure of gluteal prominence actually represents prominence and does not reflect girth. Additional support for this measure of prominence comes from the fact that the subjects were not overweight and the two groups were well matched for height and weight.

One explanation for this larger gluteal prominence in black females could be a more horizontal sacrum, which would tip the pelvis anteriorly and make the buttocks more prominent; this same horizontal sacrum would also increase the lumbar lordosis.[4] However, this study showed that, although black females did have a significantly larger APL, they did not have a larger actual lordosis as measured by either ALS or ALL. Thus, the increased gluteal prominence in blacks was not due to sacral position and most likely represented soft tissue differences. Since the position of the sacrum, which would affect the lordosis, was not different, the gluteal prominence, as soft tissue, would be well below the actual lumbar spine and would not have a significant impact on the amount of actual lordosis.

This investigation showed no difference in lumbar lordosis between black and white adult females. Fernand and Fox[3] showed no differences in lordosis between blacks and whites for both women and men. Yet the clinical perception that blacks have increased lordosis persists. This false perception may well be due to the gluteal prominence, as this study shows that black females do have a significantly larger (16.9 cm) gluteal prominence than whites (14.4 cm). This investigation was the first to objectively measure this gluteal prominence and relate that measure to the appearance of an increased lordosis. In fact, this measure of gluteal prominence may be better defined as a measure of apparent lordosis. In evaluating an individual's posture, a clinician may be following the body contours of the back and buttocks rather than looking at skeletal landmarks. In doing so, the a large gluteal prominence would tend to accentuate the actual lordosis. The clinician is being swayed by what is happening below the level of the lordosis, even below the level of the sacrum.

CONCLUSION

No significant differences were noted on ALS or ALL between black and white adult female sample populations. However, the clinical perception of increased lordosis in blacks persists. One reason for this false perception may be that the clinical assessment of lumbar lordosis is obscured by an increased gluteal prominence in blacks, even though this prominence is actually occurring below the lumbar lordosis. Significant differences were noted in gluteal prominence between black and white females, with blacks demonstrating a larger gluteal prominence. This increased gluteal prominence, although it is below the lumbar spine, gives blacks an increase in apparent lumbar lordosis.

The measure of gluteal prominence is but one explanation as to a possible factor obscuring true lordosis assessment. However, we contend that this study supports the need for conducting a full postural assessment for each patient seen with complaints of low-back pain. The clinician must avoid the bias that blacks have an increased lordosis. Each patient with complaints of low-back pain deserves a complete postural exam.

A similar study is needed to assess possible racial differences in lordosis in males. Other objective measures of gluteal prominence also may be examined to eliminate any possible investigator bias. As well, further objective explanation for the clinical perception that blacks have an increased lordosis must be examined for both sexes.

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